FAIRY TERN (STERNULA NEREIS) CONSERVATION IN SOUTH-WESTERN AUSTRALIA

A guide prepared by J.N. Dunlop for the Conservation Council of Western Australia.

Conservation Council of Western Australia ccwa Look forward

NACC Managing Natural Resources

Western Australian FAIRY TERN NETWORK

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Foreword

I have often found myself at meetings or conferences where coastal management is a subject under consideration. Awareness of a 'ternologist' in the room frequently elicits questions about Fairy Terns. These enquiries typically relate to the recurring problem of breeding failure observed in colonies in local areas that are subject to intensive human activity.

This guide takes a step back from the reactive protective measures that managers are often compelled to try when a conflict between nesting terns and people manifests on a beach or island within their patch. It tries to take a more holistic perspective on the conservation problem and to bring 'ternology' (an understanding of tern biology) to focus on the process of finding solutions at a variety of locations and on different spatial scales.

The lives of these diminutive birds interact with many coastal management issues including the health of near-shore marine habitats, shoreline stability, changing sea-level, introduced weeds, feral animals and the behavioural interactions between people and wildlife. Fairy Terns are probably threatened, or at least conservation dependent, and require dedicated species-specific management. Beyond that, however, the continued presence of these charismatic birds stands as both an indicator and a symbol of ecological sustainability in south-western Australia's coastal zone.

Nic Dunlop

Acknowledgements

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Many citizen-scientists have participated along the way but particular thanks are due to the 'bandettes' who have assisted with the research project, particularly Tegan Douglas, Kelly Rayner, Erin Clitheroe, Alison Goundrey, Lauren Gilson, Kady Grosser, Merryn Pryor, Heidi Nore, Kate Born, Claire Greenwell and Sandy McNeil.

Peter Mortimer (Unique Earth),Tegan Douglas and Cherilyn Corker kindly granted permission for the use of their quality images. Claire Greenwell kindly assisted in editing the text.

Western Australian Fairy Tern Network

Over the previous two years Fairy Tern conservation has greatly benefitted from the contributions made by participants in the WA Fairy Tern Network. The network was established by the Conservation Council (WA) using a grant from Fremantle Ports. Network communications have been facilitated by Kady Grosser, Carolyn Bloye and Claire Greenwell.

Fairy Tern photo on front cover by Jason Abuso. Fairy Tern photos on back cover (L to R) by Donna Chapman, Jesse Steele and Cherilyn Corker.

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1 The problem with small terns *(Genus Sternula)*

A group of closely related 'micro' terns are placed together in the genus *Sternula* (Bridge *et al.* 2005). These small species include the Little Tern *S. albifrons* of Europe and South-east Asia (including northern and eastern Australia), Least Tern *S. antillarum* of North America, Damara Tern of south-west Africa, Peruvian Tern *S. lorata* of western South America, Yellow-billed Tern *S. superciliaris* of eastern South America and the Fairy Tern *S. nereis* of western and southern Australia, New Caledonia and New Zealand.

Photograph courtesy of Peter Mortimer Unique Earth

Three subspecies of the Fairy Tern are recognized. These are the nominate *Sternula nereis nereis* from Australian waters, *S. nereis davisae* from northern New Zealand and *S. nereis exsul* from New Caledonia.

There are also two subspecies of the Little Tern in Australia including the nominate *Sternula albifrons albifrons* that inhabits the coastal environments of south-eastern Australia and *S. albifrons sinensis* on the tropical north coast.

The colonial breeding behaviour of terns has evolved to adapt to a variety of factors including the location of suitable foraging habitat, the synchronization of breeding with prey availability and the avoidance of predation. Small tern behavioural adaptations such as their cryptic eggs and chicks and associated flight and attack strategies were no doubt sufficiently effective to maintain populations before European occupation of Australia. Today, however, nesting on shorelines exposes small terns to reduced breeding success and adult survival due to their vulnerability to introduced predators, habitat loss due to coastal development, extreme weather events and frequent disturbance from human activities.

All *Sternula* terns nest in colonies on open shorelines including island and mainland sandy, gravelly or shelly beaches or banks of coral clinker. Colonies are generally located adjacent to protected saltwater embayments, lagoons and estuaries. Where disturbance or predation pressures and habitat losses have become unsustainable small terns have adopted sub-optimal sites (e.g. areas vulnerable to flooding) or artificial sites such as dredge-spoil or dune blow-outs. In extreme cases, small terns have even taken to nesting on the gravel bed rooves on coastal buildings as has been the case with Japanese Little Terns around Tokyo Bay (Fujita *et al.* 2009) and North American Least Terns in Georgia (Krogh 1999).

As a result of the conflict between small tern breeding behaviour and people in the world's coastal zones all species of *Sternula* have become conservation dependent in settled areas and are now considered threatened in most jurisdictions. In Australia, the Little Tern is the subject of a recovery plan in NSW and is considered threatened along the south-eastern coast whilst its status in the tropical north remains uncertain.

On the 3rd of March 2011 the Australian Fairy Tern *S. nereis nereis* was listed as threatened (Vulnerable - Criterion 3) under the Environmental Protection and Biodiversity Conservation Act (1999). This species is partially migratory and occurs in at least five States necessitating the production of a national 'Recovery Plan' (possibly combined with one for *S. albifrons*).

Little Terns *Sternula albifrons sinensis* at Wedge Island in south-western Australia.

2 The distribution and conservation status of Australian Fairy Tern populations

The Australian Fairy Tern occurs in Western Australia south of Broome, and in South Australia, New South Wales, Victoria and Tasmania. Population estimates in the 2011 Listing Advice (Commonwealth of Australia 2011) indicate that there are a few hundred pairs of Fairy Terns breeding in South Australia (mainly in the Gulfs & Coorong regions) and in Tasmania. There may be 120-150 pairs in Victoria and up to 70 individuals in New South Wales. The Listing Advice cites a population of 1600 pairs for Western Australia although this may be a significant under-estimate. All up, the population of Australian Fairy Terns is currently considered to consist of between 5,000 and 10,000 individuals across all age classes (Burbidge *et al.* 1996).

An investigation of the genetics of *Sternula nereis* was conducted across its breeding range to elucidate the conservation significance of the small (*circa* 30-40 breeding individuals) and isolated population in New Zealand (Baling & Brunton 2005). This study indicated that the New Zealand birds could be regarded as a separate sub-species *S. nereis davisae*. Another small population of 200-400 breeding individuals at New Caledonia was also given sub-species status (*S. nereis exsul*) based on this genetic analysis (Baling & Brunton 2005, Barre *et al.* 2012). Genetic differences were also detected between Fairy Terns in Western Australia and those from south-eastern Australia. However, these differences were not sufficient to merit treatment as a separate sub-species. Not surprising the highest genetic diversity was found in the largest population in Western Australia (Baling & Brunton 2005) suggesting that this region was the source for the smaller breeding groups founded in south-eastern Australia. The low genetic diversity in the satellite populations in New Zealand and New Caledonia probably reflect the genomes of a small number of founders.

Within Western Australia there appears to be a meta-population divided into three populations. Two of these are sedentary winter-breeding populations. One is based along the north-west coast from Exmouth Gulf to the Dampier Archipelago,

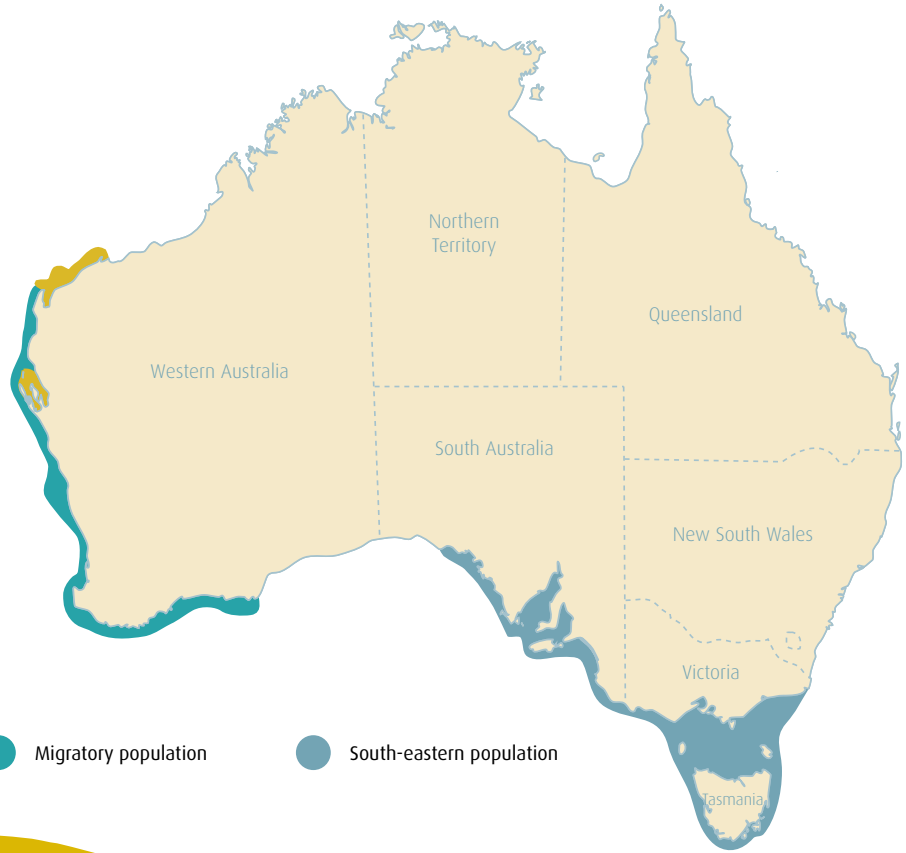


Figure 1. Map showing the distribution of *Sternula nereis nereis* including the sedentary and migratory Western Australian populations and the population in south-eastern Australia.

including Barrow Island and the Monte Bello and Lowendal Archipelagos. These Fairy Terns nest from early June to late September (Johnstone & Storr 1998; JN Dunlop pers.obs.). The second sedentary, winter-breeding population occupies Shark Bay.

The north-west coast is probably the wintering area (from June - August) for the main Fairy Tern population which breeds around south-western Australia during the spring and summer months. This population migrates south between August and October to establish breeding colonies in neighbourhoods from the Abrolhos Islands to the Recherche Archipelago. Fairy Terns are present on the mid-west, south-west and south coasts of WA from September to May (Burbidge & Fuller 2000; Johnstone & Storr 1998). Colonies may be established from October to March with a peak in nesting activity from mid-November to early January.

This Fairy Tern Management Handbook focuses on conservation measures for the Western Australian migratory population. This population experiences most of the problems with breeding failure from disturbance associated with coastal development and intensive recreational activity.

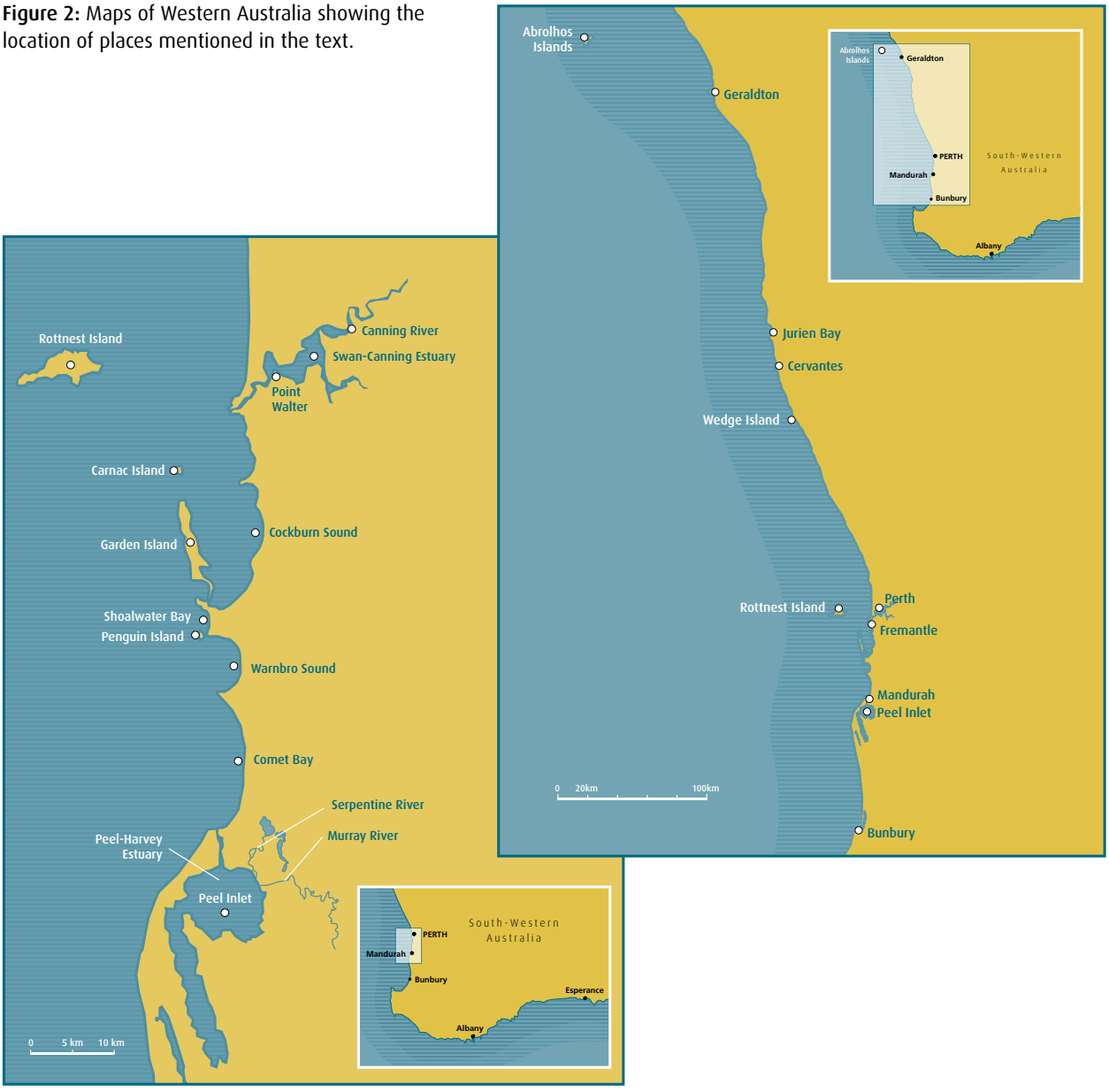
Terminology used to describe population structure in Fairy Terns

NIGHT ROOSTS	Nocturnal aggregations of Fairy Terns at specific coastal sites. Flocks contain a representative mix of age classes.
CLUBS	Shoreline locations (generally close to nesting sites) visited by terns in breeding condition to engage in paired courtship and social (group) displays.
LOCAL COASTAL SYSTEM	An area occupied by a local Fairy Tern neighbourhood and defined by its coastal features and marine habitats.
NEIGHBOURHOODS	Breeding pairs with a high probability of nesting in the same colonies. Likely to be made up of individuals from the local population of similar age and experience.
POPULATIONS	Adjoining neighbourhoods with some exchange of individuals over time.
COLONIES	Groups of interacting breeding pairs nesting in close proximity at, or within, a breeding site.
NESTING HABITATS	Areas of shoreline that are likely to attract breeding Fairy Terns. May have physical characteristics that are imprinted on young birds at their natal colonies.
NESTING SITES	Coastal locations that have attracted breeding colonies and may be used over consecutive seasons or intermittently.
RESIDENT POPULATIONS	Winter-breeding populations within the Western Australian meta-population that are resident on the north-west coast and in Shark Bay.
MIGRATORY POPULATION	The component of the Western Australian meta-population that migrates onto the lower west and southern coasts and breeds between October and March.
META-POPULATION	The combination of all Western Australian Fairy Tern populations. Only a low level of movement or 'gene-flow' is likely to take place between these populations. There are likely to be separate meta-populations in Western Australia and another in South-eastern Australia.

3 Threats to the Fairy Tern in Western Australia

Western Australia has a long coastline and there are beaches and islands where human pressures are probably relatively low or benign. However, the WA coastal environment is the focus for urban and industrial development, ports, marinas, fishing, tourism and onshore and offshore recreational activity resulting in pressures on ecosystems and conflicts with wildlife populations. The shoreline breeding habitats of Fairy Terns make them particularly vulnerable to human impacts in the coastal zone. In that sense, Fairy Terns may be a useful flagship species for natural resource management in these systems.

Figure 2: Maps of Western Australia showing the location of places mentioned in the text.



The principal known threats to the migratory population of Fairy Terns in south-western Australia are disturbance at breeding colonies, habitat loss, changes in sea-level and extreme weather events causing flooding, inappropriate habitat creation, increased predation from feral, native and domesticated carnivores and the contamination of inshore marine food-chains. These threats interact with the breeding behaviour of Fairy Terns in a way that produces a chain-reaction, where one impact triggers a response (e.g. change in colony location) that may increase exposure to another.

Disturbance at breeding colonies

The factors that control colony formation in Fairy Terns (see section 4f) lead to relatively low attachment to breeding sites. Intrusion into colony areas by potential predators (including people) particularly during the clubbing, pre-laying or early incubation periods will frequently lead to the abandonment of a nesting attempt. If this happens early in the season it may lead to re-nesting by some members of the breeding flock at another location within the foraging area or neighbourhood. Later breeding however, is likely to be less successful due to a mismatch with peak food availability. By increasing the cost of reproduction, second attempts may also reduce the survival chances of breeding adults. Forced shifts may also lead to new colonies appearing at sub-optimal or hazardous locations. In any event, the instability caused by human encroachment is likely to reduce the ability of Fairy Terns to maintain their population, at least in local areas.

If intruders (human or quadruped) do not trigger colony abandonment they may nevertheless force nest-attending parents into the air for extended periods, leading to egg or nestling over-heating on hot days or nest burial by moving sand during windy weather. Again, the outcome is likely to be reduced breeding success.

Colonies are generally disturbed by beach users including walkers (and their dogs), sun-bathers, swimmers, surfers, wind and kite surfers, beach fishers (crab-fishers in the estuaries), boat-launchers, a variety of off-road vehicle users, ultra-light aircraft and helicopters. Even bird-watchers can sometimes be too intrusive.

Habitat loss

Rising sea and estuary water levels and changes in coastal erosion and sedimentation patterns are probably the major factors contributing to natural habitat loss. Rising sea-levels caused by global warming (thermal expansion and ice-melt) are already forcing changes in shorelines. Coastal engineering such as sea-walls, groynes, boat harbours, canal developments and reclamation projects also change the pattern of sedimentation and erosion potentially removing breeding and foraging habitat for Fairy Terns. The result of these changes is that some breeding sites on beaches or sand banks become exposed to tidal flooding (e.g. Peel Estuary) or storm surges whilst others, with increased sand supply, have vegetated making them unsuitable nesting habitats. Pre-breeding aggregation sites have been abandoned due to the contraction of sand bars (e.g. Penguin Island, Rockingham) and previously secure islands have been connected to the mainland by new sand banks allowing access to domestic dogs and feral predators such as foxes and Black Rats (e.g. Tern Island Safety Bay, Wedge Island, 180 km north of Perth).

Coastal development has progressively removed nesting habitat from long-established Fairy Tern neighbourhoods. Here a colony was nesting on the last vacant block at the Mandurah Marina in 2016 (the site now has a dwelling on it).

Photograph courtesy of Cherilyn Corker.

High water levels in south-west estuaries in recent times have generally reduced the availability of roosting and breeding sites. Conversely, our drying climate has reduced run-off into the estuaries leaving entrance-blocking sandbars closed throughout the year. The consequence of this is overfilling of the estuaries resulting in the inundation of roosting and nesting sites on banks and sand-spits, and the loss of connection with the marine food-chain which provides the preferred prey species. This removal of roosting, breeding and foraging habitat from Fairy Terns leads to their disappearance from some systems (e.g. Wilson Inlet on the south coast).

Inappropriate habitat creation

As with small terns in other parts of the world, the establishment of breeding colonies on artificial or non-shoreline sites is usually immediately or ultimately the result of displacement from natural ones. In Western Australia, such surrogate breeding habitats have included dredge spoil, cleared sandy coastal areas being prepared for development, dune blow-outs, marl quarries, solar-salt fields and airstrips. Although some artificial sites appear to be beneficial (e.g. guano workings on Rat Island in the Houtman Abrolhos , Dunlop *et al.* 2015) others may expose the breeding birds to threats such as subsequent land development, flooding, inland predators (e.g. feral cats), nest burial (if sand is moving), exposure, unregulated human activity, collisions with industrial buildings, lights and wires, or contact with contaminated marine waters and prey (with heavy metals, plastic particles and pesticide residues).

Fairy Tern conservation projects involving artificial sites should, therefore, be considered a last resort and must ensure that any enhanced threats at these locations are identified and can be effectively managed.

Increased predation

Most seabirds nest on islands to avoid quadruped predators (e.g. foxes, cats and rats). Not surprisingly the introduction of these animals to islands typically has devastating consequences for seabird populations as happened, for example, on Rat Island in the Houtman Abrolhos (Dunlop *et al.* 2015). A proportion of the WA migratory population of Fairy Terns nests on the mainland shoreline where they are exposed to a range of predators. Losses are apparently minimised by nesting in open, sandy and marginal habitats away from cover, their cryptic eggs and young, and flight and distraction defensive behaviour. Fairy Terns shift colony areas periodically (even if nesting successfully) and this may be a strategy to prevent targeting by predators. As with much of our fauna, Fairy Terns will be less able to cope with introduced predators such as the Red Fox, feral cats and Black Rats than with native ones such as monitors, snakes, gulls, landrails and ravens.

Human presence around colonies may increase the risk of colony detection by predators as these animals may initially be targeting food-scraps associated with people. This is particularly so for native scavengers such as gulls and ravens. Noise from defensive birds during colony intrusion may also draw in predators. Domestic cats and dogs are likely to harass Fairy Terns near urban areas and Black Rats may be a particular problem near groynes, sea-walls and industrial areas.

Contaminants

Fairy Tern colonies locate close to prey resources (generally small schooling fishes) and can often be seen foraging within visual distance of nesting areas. The 'baitfishes' often concentrate around estuary mouths where there is enhanced marine productivity from the nutrient plume or temperature, salinity or tidal fronts concentrating plankton. Such areas are also potential areas of compromised water quality from urban and rural drainage, acid sulphate soils, canals, boat harbours, coastal heavy industries and ports. As such these areas may be foci for the bio-accumulation of heavy metals, micro-plastic particles, microbial pathogens, pesticides and the concentration of floating debris.

At present there are no data on the contaminant burden in Fairy Terns from different parts of their breeding range. Little Penguins have a similar diet and foraging habitat to Fairy Terns and these birds show elevated levels of various contaminants around south-western Australia including mercury in Cockburn Sound and selenium in the Albany waterways (Dunlop *et al.* 2013). At the remote Abrolhos Islands the binders in fabricated plastics (phthalates) were present in the preen gland secretions of 49% of the Fairy Terns sampled (Denise Hardesty pers.comm.; J N Dunlop pers.obs.). Phthalates are potent pseudo-oestrogens capable of interfering with sexual development and reproduction.

4 The ecology and breeding biology of Small Terns

Marine habitats and foraging ecology

Fairy Terns forage by plunge diving for small schooling fishes, often taken at short distances from their breeding colonies. Sometimes they can be observed fishing within visual range of their nest-sites and return with their prey held crosswise in the bill to use in courtship-feeding or to provision sitting mates or chicks. Breeding terns select relatively sheltered clear, saltwater environments that attract schools of small fishes (Johnstone & Storr 1998; J N Dunlop pers.obs.) including the lower reaches and mouths of estuaries, seagrass meadows, surf and sea-wrack zones, tide-lines and reef flats and lagoons. In the wintering area, off the Pilbara coast, relatively large flocks of Fairy Terns have been observed foraging over small tuna seaward of the reef and islands (Serventy & Whittell 1976; Dunlop *et al.* 1988; J N Dunlop pers.obs.).

In south-west coastal locations Fairy Terns have been frequently observed carrying Hardyheads *Pranesus ogilbyi*, Whitebait *Hyperlophus vittatus* and Bluesprat *Spratelloides robustus* up to about 60mm in length. At the Abrolhos Islands Fairy Terns handled during banding operations regurgitated Hardyheads between 20 and 50mm and 20-40mm, surface-schooling, post-larvae of the Black-spot Goatfish *Parupeneus signatus* (J N Dunlop pers.obs.).

Photograph courtesy of Cherilyn Corker.

High quality digital telephoto images can be used to document the prey species taken by Fairy Terns

Photograph courtesy of Peter Mortimer Unique Earth

Male Fairy Tern feeding its mate a Whitebait in the prelude to copulation (courtship-feeding).

Structured observations of the prey carried by Fairy Terns commenced in the 2016-17 season. To date 11 species of fish have been recorded by banders or citizen-science volunteers using cameras to photograph fish being carried to mates or colonies. Small schooling baitfishes predominated although small demersal or benthic species were also taken by the terns presumably while diving in the shallows. The preferred prey length was between 40 and 60mm.

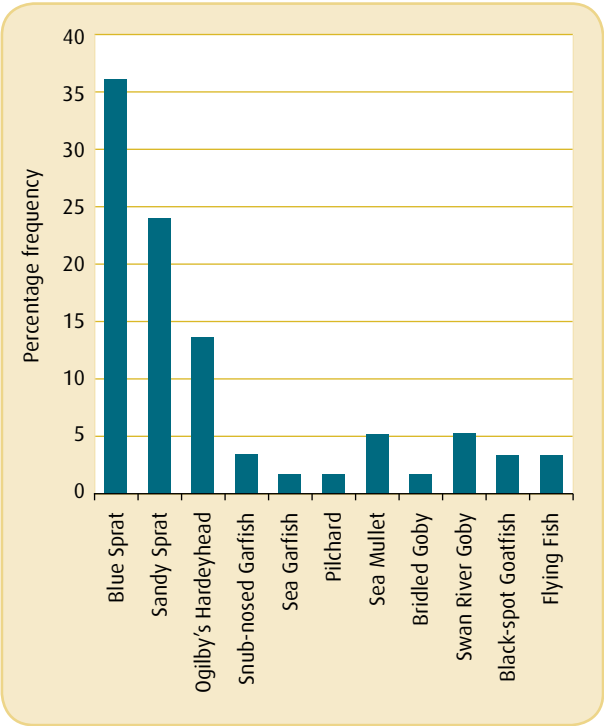


Figure 3a: Prey species taken by Fairy Terns in south-western Australia

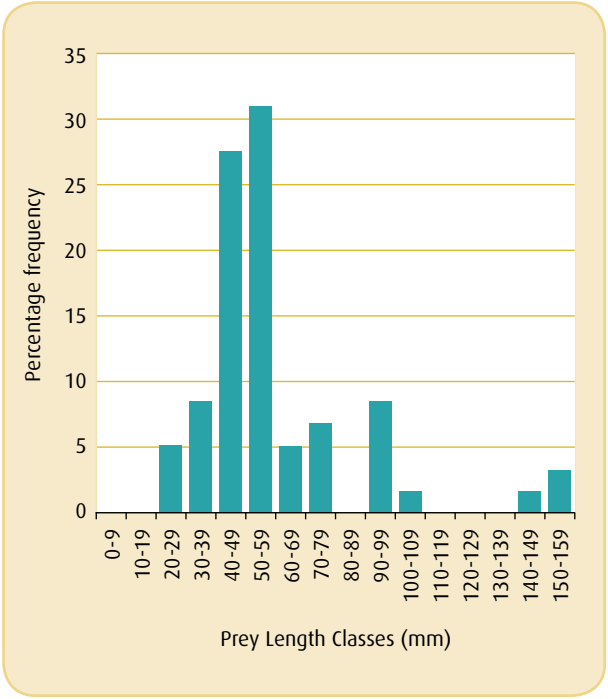


Figure 3b: Lengths of prey taken by Fairy Terns in south-western Australia.

Social behaviour

As with all other terns (Cabot & Nisbet 2013) Fairy Terns are gregarious, gathering together at roost sites both inside and outside of the breeding season. Night roosts are generally located on open shoreline features such as sandspits, away from vegetation cover and predators. Some are only occupied during the arrival period whilst others are occupied for most of the breeding season. These roosts may contain birds at a range of ages with the composition changing as the season progresses. Night roosts may include pre-nuptial and nuptial breeding experienced adults,individuals entering their first breeding season, non-breeding individuals in their first summer and fledglings (J N Dunlop pers.obs.).

The social behaviour associated with colony site-selection and establishment has not been investigated in Fairy Terns, probably because it is hard to predict when and where it will occur. Courting flocks of reproductively advanced, nuptial plumaged birds commonly occur adjacent to potential colony sites (e.g. Crested Terns - Dunlop 1987; Little Terns - Cramp *et al.* 1985; and Sooty Terns Ashmole 1963, J N Dunlop pers.obs.). Terns in these pre-breeding flocks are typically engaged in bouts of aerial courtship (i.e. 'social flights') and ground displays or parades (Cabot & Nisbet 2013). Pairs form or re-form in these flocks and paired courtship displays frequently follow bouts of group behaviour.

It is thought that the social or clubbing phase of colony formation coordinates the timing of egg-laying and the ultimate location of the colony (Dunlop 1987). Colonies may occur at the same general location for a series of seasons and then shift. Some observations indicate that the 'neighbourhood' of breeding terns return to the breeding site used in the previous year during the 'clubbing' phase but may then move in a coordinated way to a fresh location (e.g. Crested Tern - Dunlop 1987: Sooty Tern - J N Dunlop pers.obs.).

Photograph courtesy of Tegan Douglas

Large night roost on Rat Island in the Houtman Abrolhos in early April 2015.

Photograph courtesy of Peter Mortimer Unique Earth

Courtship-feeding is functionally important in Fairy Terns and a reliable indicator that nesting is imminent.

This behavioural pattern may assist in maintaining pair bonds and provide an opportunity to synchronise timely breeding with neighbours of similar age/experience and with prey availability. Younger, less experienced terns tend to lag in their reproductive cycle, lay outside the peak foraging window and as a consequence may have reduced breeding success.

Male Fairy Terns feed whole fish to their mates in a coition display that precedes copulation (Serventy *et al.* 1971). Other inshore feeding terns also bill-carry fish to their clubs as ornaments in group and paired displays, however in some of these species courtship feeding is not an obligate prelude to mating. Male Fairy Terns also feed their mates whilst they are incubating. It is likely that the ability of male Fairy Terns to provision females is an important indicator of mate quality and increases breeding performance as it does in the Common Tern (Nisbet 1973).

Breeding biology

Fairy Terns breed in colonies of up to 700 pairs (Dunlop *et al.* 2015) but typically completed colonies have between 20 and 200 nests (Johnstone & Storr 1998; J.N. Dunlop pers.obs.). At the Abrolhos Islands isolated pairs may nest within Roseate Tern colonies (Johnstone & Storr 1998, J N Dunlop pers.obs.).

Clutches consist of one or two eggs, rarely three. The relative proportions from four colonies recorded by J N Dunlop (pers.obs.) and in Storr & Johnstone 1998 are presented in the table below. Clutch sizes vary between colonies and seasons possibly related to food availability or colony age structure and the timing of the laying peak. Clutch sizes in the sedentary tropical north-western and migratory south-western populations are similar. Fairy Tern clutch sizes are smaller on average than those of the Little Tern (Cabot 2013).

Clutch sizes recorded at Western Australian Fairy Tern colonies.

Colony Location	1-egg	2-egg	3-egg
Egret I. Dampier Archipelago	30 (63.8%)	15 (31.9%)	2 (4.2%)
Abrolhos Islands	82 (62.6%)	48 (36.6%)	1 (0.8%)
Rous Head 2016	143 (79.4%)	36 (20%)	1 (0.6%)
Rous Head 2017	142 (80.2%)	35 (19.8%)	0

A typical Fairy Tern breeding colony on Carnac Island. *Photograph courtesy of Peter Mortimer Unique Earth*

Photograph courtesy of Peter Mortimer Unique Earth

Fairy Tern eggs start pipping about 3 weeks after clutch completion. Single egg clutches predominate.

Incubation duties are shared but females probably spend more time at the nest whilst males actively provision females before and after laying, as is the case with Little Terns (Cabot 2013, Cramp ed. 1985). The success of individual breeding pairs may depend on the provisioning efficiencies of the males. The incubation and fledging periods have not been precisely recorded but are probably similar to Little Terns at 18-22 and around 20 days respectively (Cabot 2013; Cramp 1985).

Photograph courtesy of Peter Mortimer Unique Earth

Fairy Terns rear one or two chicks with a fledging period of around 3 weeks.

Fairy Terns readily re-lay, typically at different colony sites if an earlier breeding attempt fails. Late colonies, from January to March, may be made up of experienced individuals on a lagging reproductive cycle, re-laying adults and birds in their second summer breeding for the first time (J N Dunlop pers.obs., section 4a).

Moult patterns in Fairy Terns

The alternate moult

As with other tern species (e.g. Dunlop 1985) the Fairy Tern has an alternate moult where the plumage and bill and leg colouration indicate the seasonal changes in gonad condition, i.e. the individual's physiological readiness to breed.

Breeding adult

Adults in breeding condition (nuptial plumage) have uniformly black caps that are sharply defined from the white forehead, the bill is bright yellow and the legs are a bright orange-yellow. A dark tip may be present in the bill particularly if the nuptial plumage has just been acquired or as a prelude to bill colour-change in the post-nuptial moult.

Photograph courtesy of Peter Mortimer Unique Earth

Incubating adult Fairy Tern in full breeding plumage. (Note absence of black bill tip.)

Post-nuptial adult

During the post-nuptial moult, the black feathers of the fore-cap are replaced with speckled feathers and the crown and dark eye-line feathers become dark grey with wear. The bill begins to lose its bright yellow colouration and the leg-colour fades.

Eclipse adult

Adults with regressed gonads in the non-breeding season have an eclipse plumage. The fore-cap is mottled merging into the white forehead and the crown and eye-line are dark grey. The bill is dark brown with faint irregular patches of dull yellow-brown and the legs are dull brown-orange.

Pre-nesting adult or 2nd year recruit

The reactivation of testes and ovaries is signalled by the replacement of the black cap and crown feathers, the yellow colouration spreading back into the bill and the heightening of the orange leg colour. In the most experienced adults the pre-nuptial moult occurs early in the season (late August and September) but probably happens later in younger birds including the terns coming into breeding condition for the first time. However, it is also apparent that within the breeding season there are waves of adults coming into nuptial plumage at different times. This suggests phase variations in the reproductive cycles of individuals and may partially explain the formation of new colonies over a lengthy breeding period (i.e. from October to March in south-western Australia).

THE BASIC MOULT

In most cases birds replace their flight, tail and contour feathers once outside the breeding season in a 'basic moult'. Terns, however, may have a pattern known as 'wave moult' where at least some of the flight feathers (primaries) are replaced twice between breeding seasons. The replacement of feathers occurs in waves and sometimes simultaneously at more than one location in the sequence from the inner primary (No. 1) to the outer one (No. 10). The examination of the condition of the primaries in adult Fairy Terns at different months during the breeding season indicates that the inner 7 or 8 primaries are replaced twice during the annual cycle whilst the longest, outer primaries (No. 8-10) are replaced once shortly after the end of breeding season. Figure 4 below shows the progression in the primary moult in samples of adult Fairy Terns captured in banding operations.

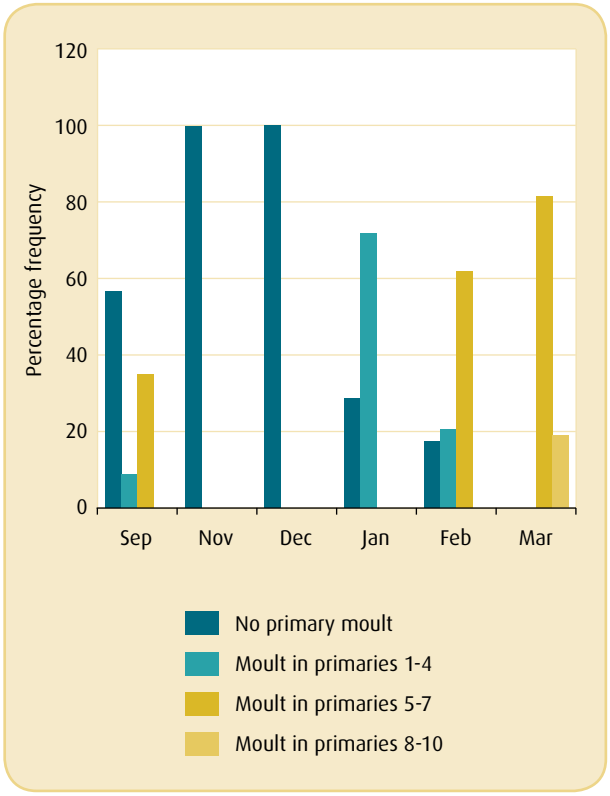


Figure 4: The progression of the primary moult in Fairy Terns captured at Penguin Island, Shoalwater Bay in September (N=28) and at Rat Island in the Houtman Abrolhos in November (N=11), December (N=17), January (N=15), February (N=29) and late March /early April (N=42).

On arrival in early September most adult Fairy Terns had completed the basic moult with the freshest feathers present between primaries 5 and 7, where the moult was arrested. Some terns lagged, with the majority still replacing the middle or inner primaries. The latter were probably pre-breeding adults.

There was no basic moult observed during the core of the breeding period in November and December. Moult resumed on the inner primaries in the majority of adults during January indicating breeding activity had ceased in these individuals. The moult progressed into the middle primaries in most adults by February, although a few (presumably late breeders) had yet to commence feather replacement. The moult commenced in the outer primaries (No. 8-10) prior to migration at the end of March / early April.

JUVENILE AND IMMATURE PLUMAGES

Fledglings / Juveniles

Fledglings, which may often be seen begging from their parents, have pale greyish-brown foreheads, buff-white crowns with a dull blackish streak from the bill through the eye to the nape. There are greyish brown to brown mottled feathers on the scapulars and

Fledgling Fairy Tern

The primary feathers on a nuptial-plumaged Fairy Tern showing the progression in the basic moult. The freshest primaries (replaced just before breeding) are numbers 7 & 8 (as counted from the innermost primary). The oldest (most worn) feathers are the outer two primaries (9 & 10). The inner six are of intermediate age. Moult in the inner primaries resumes after breeding in January and reaches the outer primaries by April.

Photograph courtesy of Tegan Douglas.

An immature Fairy Tern at the start of its second year. Note completely black bill and legs and whitish cap and crown.

Photograph courtesy of Tegan Douglas.

The head patterns of Fairy Terns at the end of the breeding season. From left to right, immature at the start of its second year, adult in eclipse plumage and adult starting post-nuptial moult (with black bill tip).

upper wing -coverts. The brown coverts persist in the juvenile terns through their first year of life until the first basic moult.

Pre-breeding immature

Immature Fairy Terns in their first summer (Year 1) have an extensive dull white forehead, pale grey crown with a narrow, dark grey eye-line, rear-crown or nape. The bill and legs are uniformly black without the brown - dull yellow bicoloured appearance of the older pre-breeding and experienced terns in eclipse plumage.

Demography, population structure and movements

Longevity

Banding records demonstrated that two breeding adults at a small colony at the Mandurah Marina in 2016/17 season were in their 20th year. These terns were originally banded as chicks (n=39) by the author in January 1997 at Tern Island, Safety Bay. These are the oldest Fairy Terns recorded by the Australian Bird & Bat Banding Scheme. The previous longevity record was for a tern banded on Rottnest Island and recaptured at Point Walter in the Swan River 17 years later. A potential longevity of between 25 and 30 years is probable for this species. The maximum age recorded for the closely related Little Tern *S. albifrons* is 21 years and for the Least Tern *S. antillarum* it is 24 (Schreiber & Ashmole 2002). Once adult, Fairy Terns are likely to have an annual survival rate above 80% (recorded at 80-93% for *S. antillarum*, Schreiber & Ashmole 2002).

Photograph courtesy of Cherilyn Corker.

A courting female Fairy Tern with a leg-band indicating that she was in her twentieth year and breeding close to the location of her natal colony.

Age of first breeding

Known age (banded) Fairy Terns have been observed at colonies as 1-year olds, as have some terns in immature plumage. However, no breeding attempt has been confirmed in these birds. Seven 2-year old Fairy Terns were recaptured whilst nesting in the Rous Head colony in the 2017-18 season and another was breeding at Point Walter in the Swan River at the same time. These observations indicate that the age of first breeding in the migratory population is 2 years, although not all individuals are likely to commence breeding at that age.

Philopatry

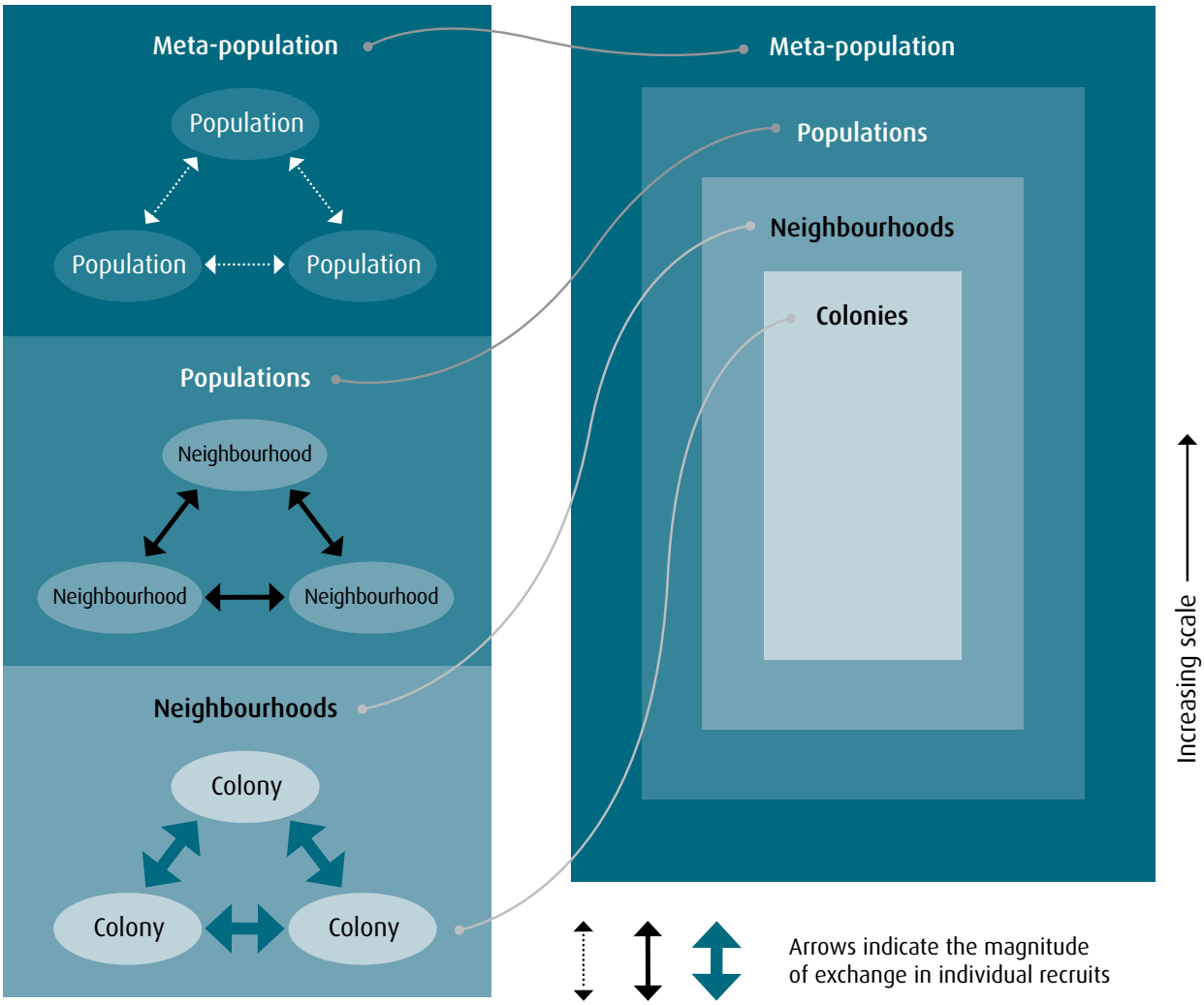
Known-age Fairy Terns have been recorded returning to their natal colony site (7 at Rous Head) and to other colonies in the same neigbourhood (e.g. Rous Head chicks to Point Walter and Lake Bagdad on Rottnest). Others were breeding within 24 km of their natal (no-longer existing) colony site after nearly 20 years. These observations indicate that Fairy Terns from the migratory population return to their natal areas (neighbourhoods) to breed, although not necessarily to the same colony site.

Photograph courtesy of Ken Glasson.

Known-age individuals (banded prior to fledging) provide a foundation for the long-term monitoring of demographic trends in Fairy Tern populations.

Philopatry (the tendency to return to the natal colony or area) produces a characteristic tiered structure in seabird populations (Figure 5). The combination of adult colony/area fidelity, insular natal recruitment (philopatry) and discontinuities in the distribution of breeding habitat or prey resources influences the movement of individuals (and therefore genes) between the different units.

Figure 5. A typical seabird population structure.



Structure of the WA Fairy Tern meta-population

The Western Australian population of Fairy Terns is isolated from those in the south-eastern States by the Great Australian Bight (Commonwealth of Australia 2011). The western population is considerably larger than in the east and has higher genetic diversity (Baling & Brunton 2005). This suggests that the Western Australian population was probably the source of the south-eastern Australian population and ultimately for the very small isolated sub-species in New Zealand and New Caledonia.

On the west coast there appears to be two sedentary populations breeding mainly from June to late September (Johnstone & Storr 1998, J N Dunlop pers.obs.). These terns nest mainly on offshore islands between Exmouth Gulf and the eastern edge of the Dampier Archipelago. Reported breeding sites include Simpson Island, Barrow Island, the Montebello Islands, the Lowendal Islands, Thevenard Island, Serrurier Island, the islands in the Maryanne Shoals and Egret Island (Johnstone & Storr 1998; J N Dunlop pers.obs). Large Fairy Tern flocks (numbering several thousand) have been observed off the Pilbara and north-west Cape (Serventy & Whittell 1976; J N Dunlop pers.obs.), indicating that the north-facing Pilbara coast is probably also the wintering area for a migratory component of the western Fairy Tern population.

A second winter-breeding and presumably sedentary population occurs in Shark Bay with breeding colonies reported on islands in the western Gulf and on Dirk Hartog Island. Wintering flocks of terns from the migratory population have not been observed in Shark Bay suggesting that these birds move further north.

Fairy Terns are largely absent from the west coast, south of Shark Bay, during the winter months from

June to early August. The birds from the migratory population start to arrive at localities further south in August (Wedge Island) and early September (Perth area). Numerous breeding sites have been recorded on islands, along the coast or in estuaries from the Abrolhos Islands in the north to the Recherche Archipelago and eastern south coast (Johnstone & Storr 1998; J N Dunlop pers.obs.). Colony sites include the beaches on offshore islands, sandy tombolos (sand bars between near-shore islands and themainland), coastal salt lakes and the beaches near the entrances to estuaries. The breeding colonies are located close to the preferred foraging habitats which are typically sheltered bays, lagoons, reef flats or river deltas. However, Fairy Terns have also been attracted to nest on dredge spoil or within cleared coastal development sites, dune blowouts, abandoned marl and guano mines, solar-salt fields and across airstrips: sometimes after being displaced from natural habitats (Johnstone & Storr 1998; J N Dunlop pers.obs).

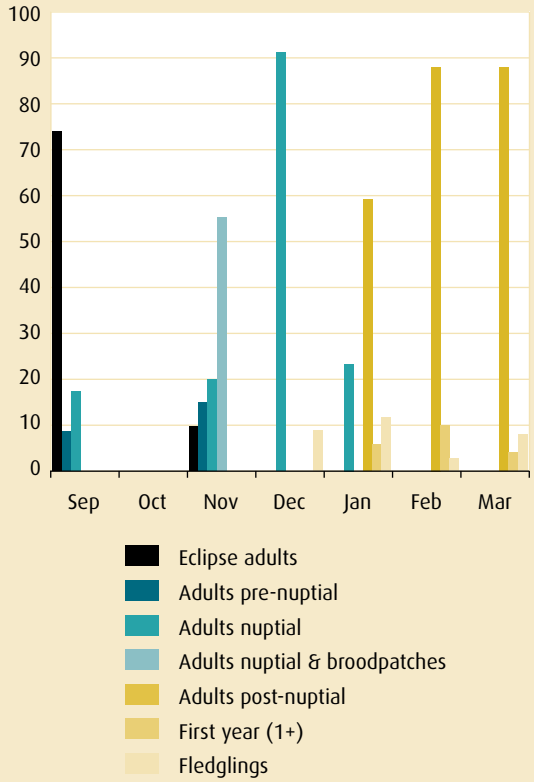


Figure 6: The age distribution inferred from the plumage, alternate moult and brood patch condition in Fairy Terns captured at Penguin Island, Shoalwater Bay in September (N=28) and at Rat Island in the Houtman Abrolhos in November (N=11), December (N=18), January (N=17), February (N=33) and late March /early April (N=48).

The plumage states of Fairy Terns captured in banding operations at night roosts have provided useful information on population structure during the breeding season in the migratory population (see Figure 6).

Night roosts that have been occupied close to the time of arrival in early September (Penguin Island, Shoalwater Bay) contained adults, most of which were still in their non-breeding (eclipse) plumage. About a quarter, however, had moulted and coloured up into their breeding plumage or were in the process of doing so. It is likely that a proportion of the eclipse-plumaged terns on arrival are birds in their second summer (2+) and sexually mature. Such birds may ultimately moult into breeding plumage and breed for the first time late in the breeding season, others may delay for another year or more. It is also likely that a proportion of the adults in eclipse-plumage at the start of the breeding season are at a different (lagging) phase in their reproductive cycles and will develop nuptial plumage later in the season and establish breeding colonies after the November-December peak (i.e. in January, February or March).

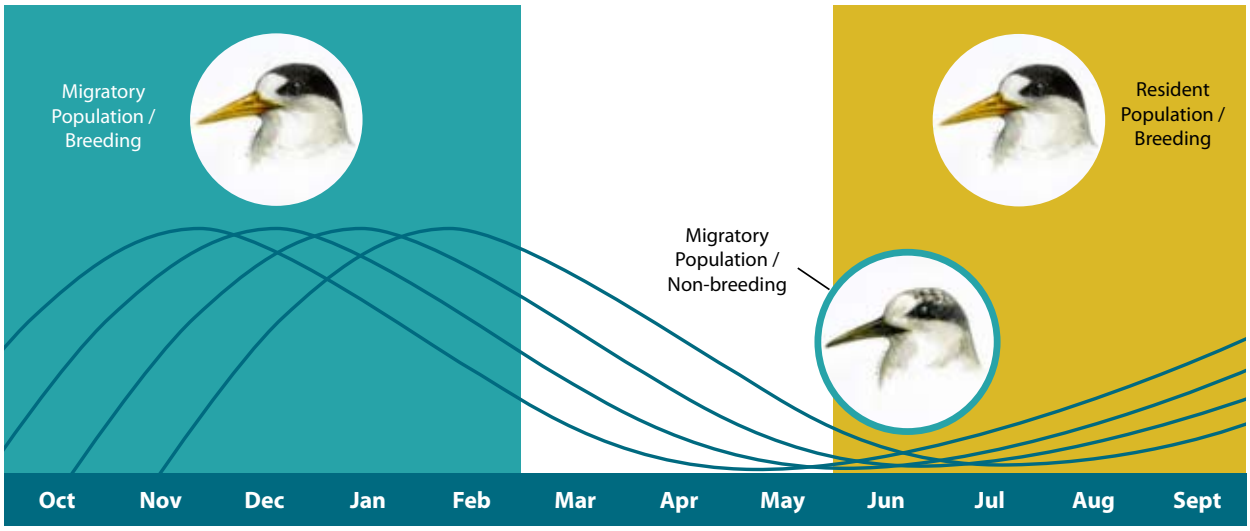
Some night roosts are not occupied until breeding has started. The roost on the airstrip on Rat Island in the Houtman Abrolhos was not occupied until November (Figure 6). At this stage more than half the adults were in nuptial plumage with active brood-patches indicating that they were breeding in colonies nearby or had recently finished a breeding attempt. Only a few adults remained in eclipse plumage and these were likely to have remained non-breeders during that season.

By December at the Rat Island night roost, all the Fairy Terns present were in nuptial plumage indicating the height of the breeding season and the first free-flying fledglings had joined the flock. By January more than half the adults had started their post-nuptial moult with mottled feathering appearing in the cap. The one year (1+) terns also appeared in the night roost at this time. In February and March most of the adults were in the post-nuptial moult state indicating that breeding had ceased. At the end of the season the flock also contained small numbers of fledglings and immature (1+) individuals.

Collectively these observations indicate that the core breeding period for the migratory population is from November to December.

From November to February, the Rat Island night roost contained from 200-400 individuals. However,

Figure 7: Reproductive periodicity in Western Australian Fairy Tern populations.



at the end of March and start of April, the numbers increased to up to a thousand (10% of the world population?). This may indicate that the western population has been somewhat under-estimated. The mark-release-recapture investigation (Conservation Council WA) shows that Rat Island (and probably other Abrolhos Islands) function as a migratory staging location for terns breeding around the Abrolhos Archipelago and for birds moving north on migration from the lower south-west coast (e.g. from the greater Perth metropolitan region).

In the case of the Fairy Tern in Western Australia the meta-population probably consists of three populations, (1) the sedentary, winter-breeding one on the north-west coast, (2) the sedentary winter-breeding population in Shark Bay and (3) the migratory population that breeds around the coast of south-western Australia between October and March. The gene flow between these populations is probably negligible due to breeding isolation resulting from phase differences in the reproductive cycle. Wintering terns from the migratory population may occupy the same region off the north-west coast during the winter months as the local breeding population, but will be in a non-reproductive (eclipse) state (Figure 7).

Fairy Tern populations may include a number of neighbourhoods (Figure 5). These are traditional areas that are used by the same flock of individuals each season, including natal recruits. The social behaviour that coordinates the timing and location of colonies occurs within these contagious groups. Although strong area fidelity will lead to most individuals breeding at one of the potential colony sites within the traditional areas, a few individuals may recruit, or shift over to adjoining neighbourhoods. Consequently, there may be a significant gene flow between neighbourhoods. Consistent breeding failure in one neighbourhood may see increasing movement to another.

Observations of plumage states indicate that there is considerable variation in the reproductive phase of breeding adults in the migratory population during the breeding season (Figure 7). Within neighbourhoods there may also be reproductively synchronized flocks of individuals, perhaps reflecting similar age and breeding experience. Colonies that start later in the season may involve younger and less experienced terns.

Breeding within neighbourhoods occurs in colonies. Colony sites may be occupied over many seasons or be transient depending on circumstances. Natal recruits may begin breeding at any colony within the neighbourhood but most are likely to return to their natal site if it is still in use. Breeding pairs are established and maintained by courtship behaviour at night roosts and club sites within the neighbourhood. Breeding adults probably frequently shift between colony sites.

Seasonal movements

The results of banding studies indicate that the dispersal of fledglings (0+) from the colonies is limited to a range of 40-50km in the first couple of months after leaving their breeding colonies. Between late

A sample of Fairy Terns captured at a night roost at the end of the breeding season (March). It included post-breeding adults in post-nuptial and eclipse plumage, pre-breeding age (1+) individuals and fledglings.

January and May the 0+ birds from Rous Head, North Fremantle were observed, often with a tending adult, up the Swan and Canning Rivers, at Rottnest Island, in Cockburn Sound, Shoalwater Bay and as far south as Peel Inlet, Mandurah. However, by March some fledglings moved northwards and were recorded 400km away at Geraldton in the mid-west and on the Abrolhos Islands. These movements indicate the start of the northward migration. Fairy Terns banded as fledglings at Rous Head have been recaptured at the night-roost on Rat Island in the Houtman Abrolhos in late March as juveniles (0+), immatures (1+) and eclipse adults (2+).

Terns colour-banded at the Rat Island night-roost in late March have been observed at day roosts and colonies in the Perth region during subsequent summers, including at Rottnest Island, Peel Inlet and Bunbury (with a chick in the breeding colony at McKenna Point, Bunbury). One tern colour-banded at Whitlock Island in Jurien Bay in March was observed two years later at Pelsaert Island in the Abrolhos. Another originally banded in October 2015 at Parkin Point, Garden Island was observed on Pelsaert Island in April 2017. These observations are all evidence of the northward movement by migratory Fairy Terns from the south-west coast in autumn. The movement pattern north of the Abrolhos Islands has not been observed and the specific location of the wintering area is currently unknown.

Flocks of Fairy Terns have been observed arriving at North Island in the Abrolhos in September. In early August, aggregations of up to 300 terns have been observed resting at day roosts on island beaches near Cervantes and on the sandbar at Wedge Island. At present this is the only information we have on the southward movement.

Factors controlling colony formation

A conceptual model of the factors controlling colony formation is presented schematically in Figure (8). The model identifies four key features in local Fairy Tern breeding systems in the migratory population, these are night roosts, foraging areas / prey aggregations, club sites and nesting habitats. The model is divided into three functional periods, arrival, breeding and pre-migration.

On arrival adult Fairy Terns in varying states of breeding readiness assemble at a night roost. These are usually sand bars, banks or open flat areas close to shorelines. The terns will forage widely searching for productive spots during the day before returning to the night roost. Over the next month or so the proportion of terns reaching breeding condition (acquiring full nuptial plumage) increases, triggering aerial group displays and courtship behaviour.

A range of locations will probably exist that provide suitable nesting habitat, usually island or mainland beaches. Site-selection may depend on where the prey (small schooling fishes) are most concentrated. Colonies are usually selected at sites that are closest to these productive foraging locations. Males carrying fish to shoreline locations for courtship-feeding will signal the availability of prey to other breeding pairs as well as provisioning the females for egg formation. Areas of shoreline adjacent to potential breeding habitat and prey aggregations may function as 'clubs', facilitating pairing and group coordination that initiates the formation of a breeding colony. It is thought that pairs of similar age and experience may have a higher probability of breeding together in 'neighbourhoods' than with other pairs. These terns may initially return to previous club sites to resume pair-bonds and reform neighbourhoods before the breeding site is selected.

Some night roosts persist after breeding commences and contain pre-breeders, immature individuals and off-duty nesting birds. Breeding terns at the colony will forage over nearby prey aggregations to meet the demands of provisioning their chicks.

Late-season nesting probably involves adults on lagging reproductive cycles, re-laying by failed pairs and initial breeding attempts by novices. However, the colony formation process is repeated. Failure at a breeding site for whatever reason early in a season is likely to trigger a shift to another breeding habitat area within the system.

Once the chicks fledge, breeding pairs disperse to forage more widely within the system and may return to the night roost. Fledglings join their parents and the other age classes in the night roosts after the breeding colony disintegrates. The northward migratory movement typically commences in March, at least for the early breeders and their progeny.

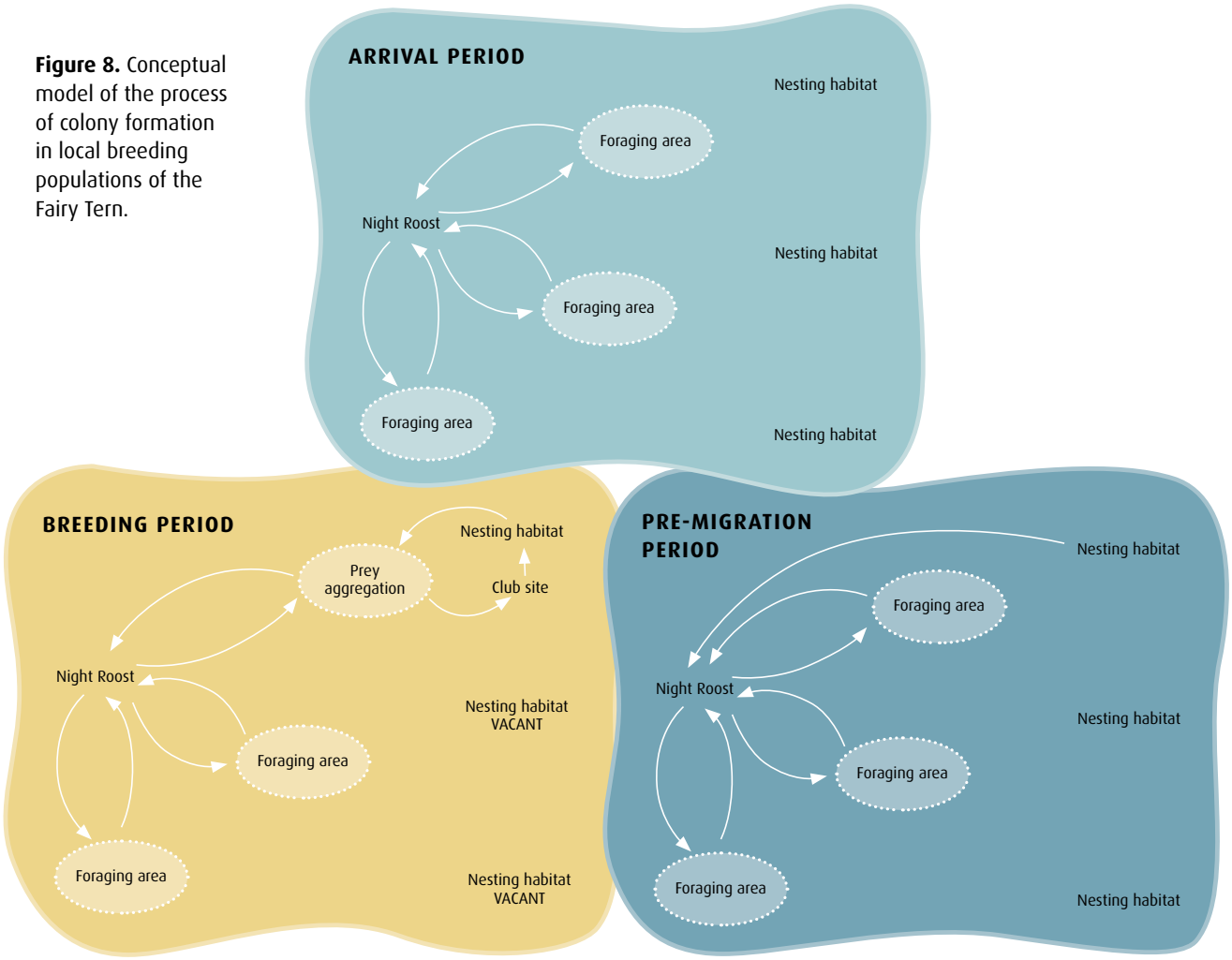


Figure 8. Conceptual model of the process of colony formation in local breeding populations of the Fairy Tern.

5 Management of Fairy Terns

Surveillance, monitoring and research

Decisions about conservation actions need to be based on short-term behavioural observations (surveillance), longer-term measurements of reproductive success and trends in local breeding populations (monitoring). The methods adopted have to consider the vulnerability of Fairy Terns to disturbance at breeding sites, particularly during the colony establishment period and early incubation. Interactions between observers and predators (e.g. gulls, ravens and domestic dogs that follow people around) also need to be considered around active colonies.

Surveillance

Local Fairy Tern management strategies need to have seasonal intelligence on how the terns are utilizing the local coastal system (neighbourhoods) to predict the location of breeding colonies. In the absence of such information, protective measures tend to be implemented when disturbance at a colony has already been occurring and this is often too late to prevent desertion or losses to predation. Critical information includes the location and occupancy of night roosts and clubs, the foraging areas and prey being taken at the former and potential colony sites.

Photograph courtesy of Donna Chapman.

Optical aids such as telescopes and binoculars are usually necessary to observe Fairy Tern behaviour and to identify banded individuals.

The capture and handling of Fairy Terns for research or monitoring purposes is best conducted at the night roosts to avoid disturbance at breeding colonies.

Finding night roosts

It appears that the Fairy Terns present in a local coastal system aggregate at night at roost sites. These will be near the tips of sandbars, on narrow sand or rubble banks, or open flat areas close to shorelines. These features may be connected to mainland shorelines or to estuarine or offshore islands. To find the night-roosts, prospective locations need to be searched with headlamps from an hour or so after sunset. The terns can sometimes be heard arriving in the twilight.

The night-roosts are representative of the neighbourhood of Fairy Terns associated with a local coastal system, as they include all the age classes. The number of birds in them is an indication of the size of the neighbourhood and the age composition may also be useful in monitoring demographic changes. The capture of adult birds for banding, or feather or tissue sampling, is best done at night roosts to avoid disturbing the terns at breeding colonies.

Foraging

The small schooling fishes taken by Fairy Terns aggregate in particular areas. These locations may, however, vary through the breeding season and from one year to the next. Common locations include the

lee-side of sand bars and tombolos (especially where there is an accumulation of sea-wrack), tidal-fronts, drop-offs and shallow reef flats.

The location of fish schools, particularly at the time the female terns are preparing to lay, will influence which potential breeding habitats (e.g. sand-spits or beaches) will effect the selection of breeding sites and attract breeding pairs to form colonies. Mapping the locations where the terns are plunge-diving for fish and plotting the flight direction of fish-carrying males will assist in predicting the subsequent location of the breeding colony. This task would be assisted by binoculars or a telescope and a hand-held GPS, but locations can also be recorded using landmarks on Google Earth maps or nautical charts.

It will also be informative for long-term management to know what the Fairy Terns are catching through the breeding season. This can be documented relatively easily using digital SLR cameras with telephoto or zoom lenses or using telescopes mounted on digital cameras (digiscopes). Modern photographic equipment is capable of getting clear head-shots of terns carrying fish (to clubs, incubating mates or chicks) at ranges of up to about 30 metres in strong light. Fish can be identified in the bill and their length estimated by comparison with beak length.

Typical nesting substrate preferred by Fairy Terns. Note the coarse sand and the scatter of shell and pebble material.

Identifying nesting habitats

Fairy Terns nest on open, un-vegetated, supra-tidal shorelines a short distance from prey aggregations. They prefer light-coloured substrates as a background for the cryptic pigment pattern on their eggs and the pale downy plumage of their chicks. The light, mottled runners (older mobile chicks) typically seek cover amongst nearby strand or foredune vegetation, beached seaweed wrack or rocks. Coarse sand mixed with pieces of shell, small pebbles or tufts of seaweed probably provides the optimal background. Clean sand may make the nests more detectable and fine sand will bury the eggs during periods of strong winds.

It is useful to map all the locations within a coastal system that meet the nesting habitat image for Fairy Terns. These will include natural sites such as coastal, island and salt lake beaches, banks, dune-blowouts and sand-spits. Artificial sites also need to be considered including coastal sand, limestone or guano quarries, solar salt or gypsum ponds, dredge-spoil, cleared development footprints and even the limestone aprons on airstrips. Sites that have been used in previous seasons have a higher probability of being used again, sometimes over several consecutive years.

Monitoring

Surveillance information will be central to the development of local Fairy Tern Conservation Strategies (see section 5f) and will also provide a benchmark for a subsequent monitoring program. Monitoring itself involves periodic, structured observation that is designed to provide the information required to assess the effectiveness of conservation measures in an adaptive management (learning by doing) framework (Dunlop 2009). In the context of Fairy Tern management the collection of monitoring data needs to focus on conservation outcomes such as the size and age structure of the local Fairy Tern neighbourhood and annual breeding success.

Local population size and breeding performance

The best focal points for assessing local population size and age structure are the night roosts. However, the collection of data usually requires roosting terns to be captured in mist-nets and banded to provide for the long-term identification of individuals. These methods are not available to volunteers without the appropriate training and licenses, however such work could be conducted in partnership with researchers or groups like the Conservation Council (WA) Citizen Science Program, BirdLife WA, the Western Australian Bander's Association or the Western Australian Wader Study Group.

Another way to collect local population data is by the coordinated and synchronised observation of resting Fairy Terns at all of the suitable shorelines within the coastal system. This work may require both land and boat-based observers with binoculars or telescopes. The observers need to record the number of birds at each location, preferably dividing the count into individuals in the different moult or plumage phases (see Section 4d) representing different age classes. October will generally be the best month to assess local population size.

During the post-breeding period in late February/early March the resting flocks of Fairy Terns will contain the fledglings (0+, see Section 4d) produced in the local colonies during that season. These can be counted and the ratio of fledglings to adults (excluding 1-year old immatures - Section 4d) would be a potential index of local reproductive output. Getting an accurate count of nests in breeding colonies is usually difficult without causing significant disturbance, although some sites may have vantage points that make that possible.

Research

At this stage the functional importance of local Fairy Tern breeding populations as management units is not understood. For example, are all local breeding groups important to maintain overall population size or is there a source and sink structure where the protection of some areas is more important than others? This is a research question that could be answered by a long-term banding study.

A long-term banding project coordinated by the author and conducted through the CCWA Citizen Science Program commenced in 2013. Adult

Research projects will be needed to better understand the structure of the Western Australian Fairy Tern meta-population.

Photograph courtesy of Cherilyn Corker.

The tiny numbers on metal bands can sometimes be deciphered using telephoto images from modern digital cameras.

(breeding) and fledgling (known age) terns have been marked from different areas within south-western Australia. Individuals are recaptured or re-sighted within, or when moving between locations, over several seasons. This data has already assisted in assessing the level of area fidelity (philopatry) and interchange between local neighbourhoods or populations. Volunteer observers have enhanced these banding studies by reporting the location of colour-marked Fairy Terns and the band numbers from individuals found dead or injured. Some observers have provided vital records on longevity and site fidelity by photographing the numbers on metal bands worn by terns observed at migratory day roosts and at breeding colonies.

The DNA sequencing of individuals from different local populations may also elucidate the conservation management units within the Western Australian meta-population. This can be done from feather samples.

Nesting habitat management

Fairy Terns do not retain the same nest site from one breeding attempt to the next. Colonies, however, may establish in the same general locations in consecutive years or re-use certain places intermittently. Shoreline sites are subject to rapid change due to sand erosion or accretion, tidal cycles and sea-levels, beach-wrack movement and deliberate modification. Locations that have been used in the past may be lost, become less attractive to the terns, or be subject to increased disturbance or predation.

Photograph courtesy of Peter Mortimer Unique Earth

Older chicks (runners) vacate the nesting area and seek cover amongst foredune vegetation, beach-wrack, flotsam or rocks. Artificial chick-shelters may improve fledging success by providing protection when natural cover is lacking.

Colony sites that are attractive to breeding pairs may develop naturally or result from coastal development activity including the clearing or loss of dune vegetation, the dumping of dredge spoil or beach-engineering. Conversely, sites that are well above the coastal strand, may become vegetated with native dune vegetation or covered by introduced weeds making them unusable.

Intervention may be necessary to increase the probability that one or more secure sites will be utilized, or alternatively, to prevent breeding Fairy Terns being attracted to inappropriate locations. Potential breeding sites that result from development footprints or coastal engineering may put nesting terns at risk of breeding failure and increased adult mortality.

Colonies that appear in development areas can hold up projects causing financial losses or conflict with patterns of recreational activity. Either way, such sites need to be treated to make them unattractive prior to the start of each breeding season. In the short term the ground surface can by hydro-mulched incorporating a dark-coloured dye or covered with straw-bales. Ultimately, if the site is not to be sealed or built on it will need to be re-vegetated.

In the absence of sufficient active or alternative protected breeding sites in the local coastal system, steps may have to be taken to enhance the attractiveness of naturally developing or artificial habitats. This could involve reducing the vegetation cover, contouring the surface to produce low berms, or adding shell or limestone pebble material to otherwise visually uniform substrates. Local shell material to enhance preferred nesting sites has been sourced from Pacific Gull anvil sites, and in one case, the coarse screenings from a marine lime-sand operation were utilised. In the absence of cover for the runners at the margins of the planned nesting area, simple shading 'chick-shelters' can be placed to increase fledging success. These can often be constructed from local rocks or driftwood.

Adding shell material to the sandy surface can increase the attractiveness of potential colony sites to prospecting Fairy Terns.

In coastal areas where human use pressures now prevent Fairy Terns from breeding successfully there is growing interest in establishing secure managed (including specifically engineered) sites. These may be dredge-spoil islands in strategic locations or even floating islands landscaped to provide breeding habitat. In the absence of legal protections, however, even these sites may not be secure from human disturbance.

Protecting colonies from human encroachment

The presence of people or their dogs close to a Fairy Tern breeding colony will elicit an anti-predator response. The nest-tending adults will take to the air to avoid disclosing the location of the eggs or young and then will engage in noisy concentrated dives on intruders. Direct physical contact is avoided but the terns will accurately defecate on interlopers or foreign objects within the nesting area.

Disturbance events during the colony establishment or early-laying period will often lead to the abandonment of the site (a predator avoidance response). Re-laying may occur elsewhere in the coastal system. Protracted disturbance later in the nesting cycle may cause un-attended eggs or chicks to chill or overheat, clutches to be buried in moving sand or attract predators. Commensal predators such as gulls, ravens or dogs may follow people (or their rubbish) to colonies and then prey on Fairy Tern eggs or chicks. Gulls and ravens in particular may opportunistically plunder exposed nests during periods of human disturbance.

Three strategies have been employed to try and protect beach nesting birds (including Little and Fairy Terns) from human disturbance. These are community education, signage (combined with boundary delineation) and volunteer wardens.

Fremantle Ports have constructed and managed a highly successful Fairy Tern breeding site within the container port at Rous Head, North Fremantle.

Education

Education can be a two-edged sword because vandals inspired with a little knowledge can do a lot more damage. However, on balance, particularly at the local community level, education programs can increase awareness of an issue, change environmental values and modify behaviour.

Different approaches are needed to develop awareness in a variety of target audiences. The targets for educational programs include:

- children (and through them their parents)
- local coastal communities
- coastal associations - for activities such as off-road vehicles, boating, surfing (including wind and kite-surfing), and commercial and recreational fishing; and
- agencies such as the Department of Defence, Local Governments and Port Authorities - these bodies often control areas that are used by breeding Fairy Terns and need to be informed to facilitate their approval (and perhaps participation) for conservation actions.

Specific curriculum based educational materials for children need to be developed for coastal conservation issues in Western Australia. Resources for teachers are currently limited. Birdlife provides a 'Beach-nesting Birds Educational Kit' focussed on South Australia that has some teaching ideas that could be adapted to Fairy Terns in a Western Australia context.

Local Fairy Tern conservation strategies may need specific proposals to engage the teachers within coastal communities.

Key messaging to all target groups should focus on how each individual, group or organization could contribute to solving the problems with Fairy Tern conservation rather than identifying their activities only as threats. Targeting holiday-makers from outside local coastal communities and people who don't engage with organized clubs or associations can be difficult. Building the capacity for 'peer pressure' to be exerted through aware local beach/island users may be the best strategy to deal with the 'non-local' and 'non-organized' visitors to areas with Fairy Tern colonies.

Signage and boundary marking

Two kinds of signage might be employed in a Fairy Tern management strategy, as they are for other beach-nesting birds (Maguire 2008).

Interpretative signage would convey information about Fairy Terns, their nesting behaviour and the threats to their survival within a particular coastal system. Typically, it would be used at access points to beaches or at boat-launching facilities,other focal locations for visitors and at managed Fairy Tern colony sites. The same information could also be produced in poster-form for display at public buildings (e.g. libraries) and in holiday accommodation. Interpretive signage would probably not be deployed at breeding colonies unless they have a history of high-

Photograph courtesy of Peter Mortimer Unique Earth

Protective signage encircling a Fairy Tern breeding colony on Carnac Island.

frequency occupation (perhaps half the seasons over a 10-year period). Interpretive signage needs to be designed for its long-term location with an attractive design and constructed from environmentally compatible and durable materials. A 'house style' may assist by badging Fairy Tern conservation as a widespread WA conservation program.

Protective signage directly warns people of the potential consequences of disturbance from entering into an area where Fairy Terns are nesting, or of outside activities that might elicit anti-predator responses. Such signage is deployed temporally at sites where Fairy Terns are exhibiting pre-laying behaviour or where nesting has commenced. Protective signage is usually deployed with other boundary markers such as temporary fencing or by roping-off.

Protective signage needs to be durable and suitable for rapid transport and deployment. The signage needs to be deployed facing the likely direction of public approaches to the site from beach or other access points. The setback distances from the nesting terns, delineated by the protective signage and boundary markers, need to be sufficient to prevent anti-predator responses during the settlement period (during egg-laying). The selected boundaries also need to take into account the likely expansion of the colony from its centre and the nearby cover that might provide shelter for older, mobile chicks (runners).

Fairy Tern colonies on island beaches are difficult to protect (even though most are nature reserves) because the visitors land from boats and there is rarely enough space available to provide an adequate buffer. Protective signage may need to be deployed on floating marker buoys and landing prohibited during the breeding period.

Brightly coloured, flapping bunting (commonly used for safety barriers) should not be used anywhere for boundary marking as it will itself induce alarm amongst the nesting terns. Avoid using new rope as this is usually stolen within a couple of days.

Permanent or long-term ring-lock fencing has been used to protect the nesting areas of beach-nesting birds (Maguire 2008), particularly birds that nest high on the beach or in the foredunes. This may be considered for some stable artificial sites (combined with social facilitation techniques- see Section 5). However, its general application is negated by the regular shifts in colony location and the beach erosion cycle.

Volunteer wardens

Volunteer wardens might provide two major services (Maguire 2008):

1) surveillance of active colony areas and maintenance of on-site protective installations (e.g. signage, boundary markers, barriers and chick shelters); and
2) Face to face, on-site engagement with the public;

Wardens need to be:

- trained in the management of Fairy Terns and be implementing a local Fairy Tern Management Strategy (see Section 5f);
- trained to interpret the natural history of Fairy Terns to the public with the assistance of portable props, telescopes, brochures etc.;
- authorized to adjust protective boundaries in response to changes in the colony under pre-determined circumstances;
- clearly identified as volunteer wardens with badges or a uniform (e.g. stencilled on T-shirts or badged on windcheaters). High visibility work clothing should be avoided near seabird colonies;
- in close contact with wildlife officers or rangers from the conservation agency;
- supported by agency staff when tern protective systems fail or in the face of non-compliant or hostile visitor behaviour;
- able to report periodically on the progress of the breeding terns and the public response to the protective measures.

Protecting breeding colonies from predators

Most Western Australian seabirds breed on our small continental islands to avoid mammalian predators. Fairy Terns, however, also breed at sites along the coastline presumably accessible to near-shore concentrations of small schooling fishes. The breeding strategy adopted by Fairy Terns (including the regular shifts in nesting areas) is probably, in part, an adaptation to avoiding targeting by land-based predators.

At mainland sites nowadays the major mammalian predators of Fairy Terns are foxes, cats, Black Rats and domestic dogs. Silver Gulls and Australian Ravens are the principal avian predators. During the surveillance of potential breeding sites it is useful to search for signs of predator activity, either from direct observation, tracks (including prepared sand-pads)

or using motion-detector cameras. Any anti-predator interventions need to be timely if they are going to be effective.

Managers need to be aware that the presence of people around colonies, including staff and conservation volunteers/wardens, may attract predators (that are also scavengers) to a colony area or provide opportunities for them to locate and plunder the nests. Signs, fence-posts and other structures erected to protect colonies may become observation posts for ravens or kestrels, increasing the risk of predation (although spikes in the top of fence posts can prevent this). Rubbish bins or fish-cleaning stations that attract gulls, ravens and rats should be relocated if they are near beaches with Fairy Tern colonies.

Baiting programs for foxes, cats and rats can be carried out on the island nature reserves and at remote coastal locations but are generally not an option in public spaces, such as coastal recreation areas, due to the risks to children and pet animals. Soft-jaw traps baited with scent lures (urine or faeces) can be an effective low risk method for the targeted removal of foxes and cats in these areas. These traps are designed for live capture and not in themselves likely to harm the predator or other non-target animals (e.g. domestic dogs). The use of scent lures rather than food baits reduces their attractiveness to other species.

Another method to reduce nest predation from both introduced mammals and native birds is 'conditioned taste aversion' (CTA - Maguire 2008, Maguire *et al.* 2009). Dummy eggs from a domestic bird (e.g. quails) are laced with an emetic, inducing a short period of sickness when ingested by a predator, which then develops a foraging aversion for the eggs of the protected species. The eggs are deployed in artificial nests within the breeding area. For the protection of beach-nesting Hooded Plovers 40mg of water-soluble and odourless sodium carbonate crystals were seeded into Common Quail eggs. These were taken by foxes reducing the subsequent predation rate (Maguire *et al.* 2009).

Lethal baiting generally only provides short-term relief from predators as the vacant territories of dead animals are rapidly filled by dispersing recruits. The advantage of the CTA methodology is that the territories occupied by the conditioned individuals continue to exclude others effectively defending the protected species. Conditioned taste aversion methods are likely to be particularly effective for intelligent native bird predators like ravens where information about food availability (or toxicity) is rapidly transmitted by birds in a family group or flock.

Breeding facilitation techniques

One approach to improving Fairy Tern breeding performance within local coastal populations is to encourage the terns to select secure or manageable nesting sites. This can be done using social facilitation techniques that involve the deployment of decoys (models of incubating terns) in configurations that mimic the early stages of colony formation. The effectiveness of the decoy colonies can also be augmented with continuous playback of contact (flock) or advertising calls, although this may not be necessary for all situations.

Decoy colonies have been used successfully on tern species that do not retain nest sites between breeding attempts and coordinate colony formation in pre-breeding group displays (e.g. Dunlop 1987). Social facilitation methods have been used effectively on

Models of incubating Fairy Terns (decoys) combined with playbacks of Fairy Tern flock calls can be used to encourage prospecting pairs to settle within managed sites.

Crested, Caspian, Sooty and Least Terns and have proved to be effective for Fairy Terns. The basic pre-conditions for attracting terns to a preferred location are an appropriate nesting habitat type, overflying terns in breeding condition and sufficient prey resources within an economic foraging range.

Preferred nesting sites for Fairy Terns, whether natural or artificial, need to be identified in the local Fairy Tern Conservation Strategy (section 5f). There will probably need to be a number of alternatives reflecting the variability in productive foraging locations. Next, local surveillance will need to detect Fairy Terns in nuptial plumage passing through or utilizing the selected location and confirm that terns are actively foraging with about 2km. If these pre-conditions are met the decoy colony can be deployed in the preferred nesting area.

Experience suggests that the decoys, mimicking incubating birds, should be deployed at about double natural colony-spacing (Dunlop 1987). That is about 2m intervals for Fairy Terns. This will encourage the first tern pairs to settle between the decoys in the core of the selected nesting area, reducing the number of nests occupied near the extremities. Signage or other protective measures can then be located with reasonable confidence around the ultimate nest locations.

Local Fairy Tern conservation strategies

Conservation objectives

It is likely that the critical population unit for Fairy Tern conservation equates to the neighbourhood (i.e. a group of adult individuals with a high fidelity for a natal area) rather than to individual colonies. A search of the recent breeding records for the Fairy Tern, and the results of the banding program, suggest there are seven management units in Western Australia, five for the migratory population in the South West (Figure 9).

Local Fairy Tern management strategies need to be developed, or updated, for all of these management units beginning with the ones facing the greatest threats e.g. lower west coast (the greater metropolitan region), the mid-west coast and the western south coast.

Section 5 described the process of colony formation in Fairy Terns and the key functions of night roosts, foraging patches, clubs and nesting habitat in each coastal system. Structured surveillance programs are needed to determine where these locations may be and to map them for presentation in a plan.

The development of a Local Fairy Tern Conservation Strategy (the Strategy) requires historical information on the activity of Fairy Terns in the system to be compiled and current information from surveillance conducted by trained observers. Historical breeding events may be documented but, in many cases, the information will exist only as unreported local knowledge.

The Strategy should define the boundaries of the coastal system with a local Fairy Tern neighbourhood and a map or maps showing:

a. the location of the night roost or roosts (these areas may change seasonally);
b. the location of productive foraging areas;
c. the known locations of previous Fairy Tern breeding colonies;
d. the locations of potential breeding habitat (natural and artificial); and
e. the agency / agencies or private interests that control the land or water within the coastal system (N.B. there are often numerous overlapping jurisdictions on the coastline).

The map should be annotated by a description of the key functional areas as part of an overview of Fairy Tern foraging, social and nesting behaviour within the relevant coastal area.

The Strategy should then identify any human-induced pressures operating at key Fairy Tern roosting, foraging or nesting areas that may require the implementation of protective measures to maintain the local neighbourhood. This could be summarized in a three column PRESSURE - STATE - RESPONSE table where for each key functional area;

the PRESSURE - is the degree of human induced change to Fairy Tern survival or reproductive rates;

the STATE - is the current level of foraging success or breeding output or group size; and

the RESPONSE - is the management intervention required to maintain Fairy Tern survival and reproductive rates.

The Strategy will then need to devise a monitoring program that measures the STATE of each functional area, and of the local Fairy Tern population, to detect changes in the amount of PRESSURE and effectiveness of the management RESPONSE.

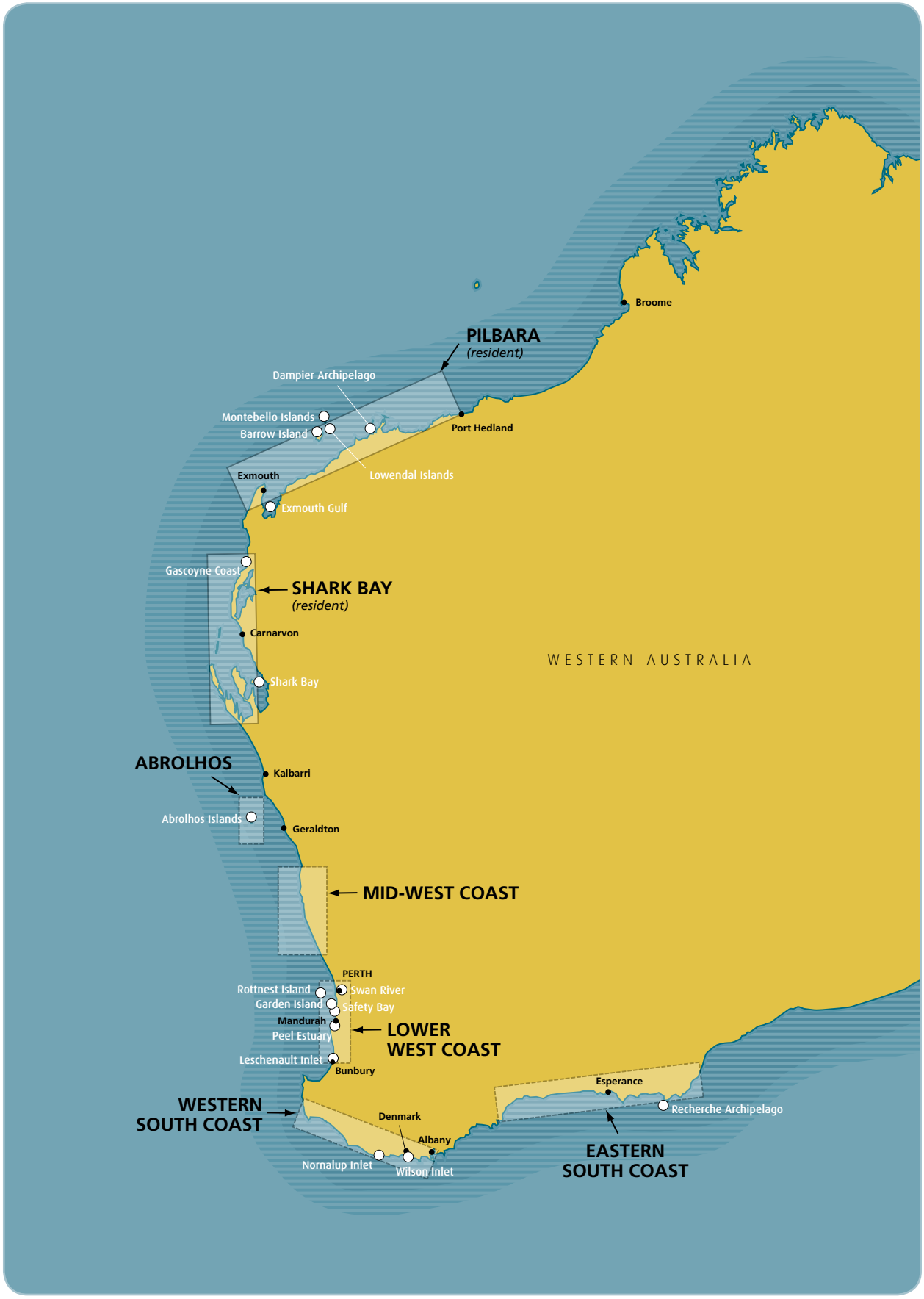


Figure 9: Proposed Conservation Management of Western Australian meta-population of the Australian Fairy Tern.

Nowhere is the allocation of statutory responsibility for management more complex than on the coast. Key functional areas for local Fairy Tern populations could occur in unallocated crown land/water, shire coastal reserves, terrestrial (including island) nature reserves, marine parks, reserves vested in the Minister for Fisheries, coastal fishing and aquaculture leases, Department of Water controlled areas, Department of Transport controlled areas, the Swan River Park, marinas and boat harbours, mining licences or leases, native title claim areas, Department of Defence areas, Port Authority areas, water-front commercial leases, private land and so on. Needless to say, no management action to protect Fairy Terns at any particular location can occur without the permission, cooperation or partnership agreement of at least one other entity.

In most coastal systems Local Fairy Tern Conservation Strategies will need to be owned, and in some-cases formally adopted, by a range of stakeholders and management authorities. Wherever possible, however, the strategies should attempt to utilise, to the greatest extent possible, lands and waters securely reserved for 'nature conservation' purposes (e.g. in the selection of preferred nesting areas).

A recommended structure for a Local Fairy Tern Conservation Strategy is outlined below.

1. Title - Should clearly identify the coastal system or region with breeding Fairy Terns.
2. Overview of the local Fairy Tern neighbourhood in the coastal system (based on historical records and a recent surveillance program). Include a map showing the key functional areas for the local Fairy Tern population.
3. The pressure-state-response analysis for each key functional area for the local Fairy Tern population.
4. Proposed protective management measures for key functional areas (if required). Sub-headings might include:
    - surveillance, monitoring and research
    - nesting habitat management
    - protecting colony areas from human encroachment (education programs, signage, boundaries and fencing, volunteer wardens)
    - protection of breeding colonies from predators; and
    - breeding facilitation projects.
5. Establishing a local Fairy Tern volunteer conservation network or group
6. Engaging stakeholders and developing partnerships
7. Obtaining approvals and negotiating management agreements

The Strategy should include a map showing the jurisdictional boundaries for the agencies or private interests controlling the management of land or water within the coastal system (N.B. there are often numerous overlapping jurisdictions on the coastline).

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About the Conservation Council of WA

The Conservation Council of WA (CCWA) is the State's foremost non-profit, non-government conservation organisation. We are an umbrella group for over 100 affiliate conservation groups and have been an outspoken advocate for environmental protection and a sustainable WA for over 40 years.

The CCWA Citizen Science program supports community groups and individuals in undertaking ecological monitoring in order to build the knowledge and understanding that is critical to the conservation and management of our natural environment.

Dr. Nic Dunlop is CCWA's ecologist and Citizen Science Coordinator and has been studying terns in Western Australia and elsewhere for over 30 years. During this time Nic has advised many agencies and community organisations on seabird conservation and published numerous reports and journal articles on tern ecology.

You can find out more, and support CCWA's conservation and citizen science work by visiting the CCWA website at www.ccwa.org.au

Piers Verstegen
Director



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